Researchers design trees that make it easier to produce pulp

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Credit: Notneb82, Wikimedia Commons

Researchers have genetically engineered trees that will be easier to break down to produce paper and biofuel, a breakthrough that will mean using fewer chemicals, less energy and creating fewer environmental pollutants.

"One of the largest impediments for the pulp and paper industry as well as the emerging biofuel industry is a polymer found in wood known as lignin," says Shawn Mansfield, a professor of Wood Science at the University of British Columbia.

Lignin makes up a substantial portion of the cell wall of most plants and

is a processing impediment for pulp, paper and biofuel. Currently the lignin must be removed, a process that requires significant chemicals and energy and causes undesirable waste.

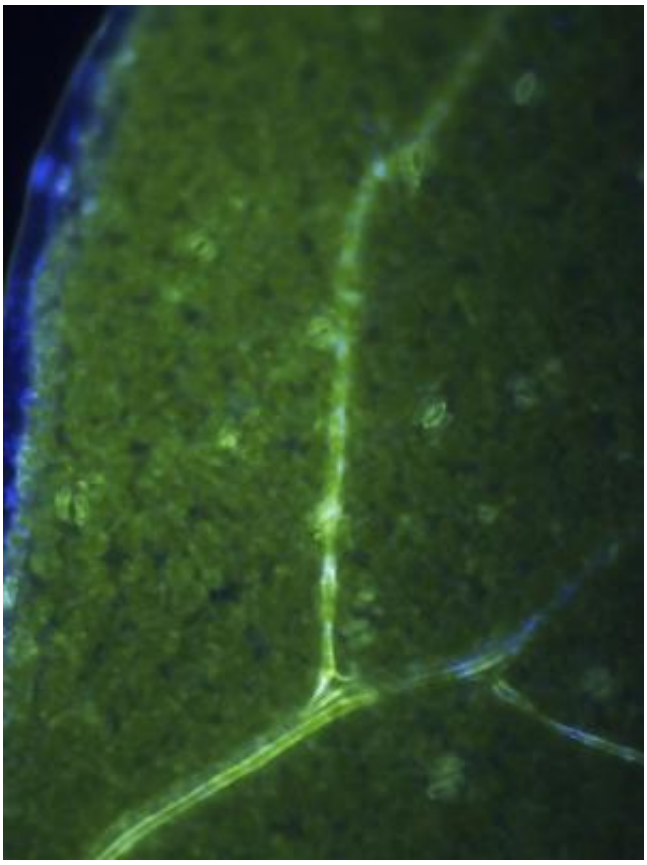
Researchers used genetic engineering to modify the lignin to make it easier to break down without adversely affecting the tree's strength.

"We're designing trees to be processed with less energy and fewer chemicals, and ultimately recovering more wood carbohydrate than is currently possible," says Mansfield.

Researchers had previously tried to tackle this problem by reducing the quantity of lignin in trees by suppressing genes, which often resulted in trees that are stunted in growth or were susceptible to wind, snow, pests and pathogens.

"It is truly a unique achievement to design trees for deconstruction while maintaining their growth potential and strength."

The study, a collaboration between researchers at the University of British Columbia, the University of Wisconsin-Madison, Michigan State University, is a collaboration funded by Great Lakes Bioenergy Research Center, was published today in *Science*.



Introducing really cleavable linkages into the lignin polymer backbone. Lignins are polymers integral to plant cell walls derived from combinatorial radical polymerization of hydroxycinnamyl alcohol monomers. Delignification requires cleavage of the polymer into smaller soluble units, but breaking even the weakest backbone bonds requires stringent chemical conditions. We have induced plants to synthesize monolignol ferulate conjugates in their monomer pool, by using a gene from Chinese Angelica, and to utilize them for lignification. Using a xylem-specific promoter, the protein is targeted explicitly to the vascular tissue of the leaf (as shown here by the fluorescence) and, of course, in the wood. This produces lignins that are more easily depolymerized, providing less energy-demanding access to the valuable plant polysaccharides. Credit: Shawn Mansfield, UBC, and editing by Matt Wisniewski, Media Specialist, Great Lakes Bioenergy Research Center, Madison, WI

Background

Lignin

The structure of lignin naturally contains ether bonds that are difficult to degrade. Researchers used genetic engineering to introduce ester bonds into the lignin backbone that are easier to break down chemically.

The new technique means that the lignin may be recovered more effectively and used in other applications, such as adhesives, insolation, carbon fibres and paint additives.

Genetic modification

The genetic modification strategy employed in this study could also be used on other plants like grasses to be used as a new kind of fuel to replace petroleum.

Genetic modification can be a contentious issue, but there are ways to ensure that the genes do not spread to the forest. These techniques include growing crops away from native stands so cross-pollination isn't possible; introducing genes to make both the male and female trees or plants sterile; and harvesting trees before they reach reproductive maturity.

In the future, genetically modified trees could be planted like an agricultural crop, not in our native forests. Poplar is a potential energy crop for the biofuel industry because the tree grows quickly and on marginal farmland. Lignin makes up 20 to 25 per cent of the tree.

"We're a petroleum reliant society," says Mansfield. "We rely on the same resource for everything from smartphones to gasoline. We need to diversify and take the pressure off of fossil fuels. Trees and plants have enormous potential to contribute carbon to our society."

More information: Paper: "Monolignol Ferulate Transferase Introduces Chemically Labile Linkages into the Lignin Backbone," by C.G. Wilkerson et al *Science*, 2014.

Provided by University of British Columbia